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Compressor Dry Gas Seal Failure Due To Oil Ingress

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Case study abstract

This case study of a typical tandem arrangement dry gas seal failure during compressor start-up elaborates importance of start-up environment consideration during design for a compressor dry gas seal system. The seal failed due to oil ingress during compressor start-up.

The case study presentation details out following major contents:

- Chronological events leading to dry gas seal failure, relevant data
- Findings/observations during subsequent maintenance
- Root cause analysis and outcomes
- Corrective actions & subsequent performance
- Key learnings

Equipment Details

Compressor

Service: RGC, Recycle Gas (Hydrogen)

Compressor Type: Centrifugal, Barrel

Rated Speed: 10631 RPM

Rated Power: 2992 KW

Seal Type: Dry Gas Seal

Discharge Pressure: 79 kg/cm2A

Location: Hydrotreater, Refinery

Seal

Type: Tandem arrangement with intermediate labyrinth (Barrier seal included)

Shaft Size: 132.0 mm

Dynamic pressure: 60.33 kg/cm2 A

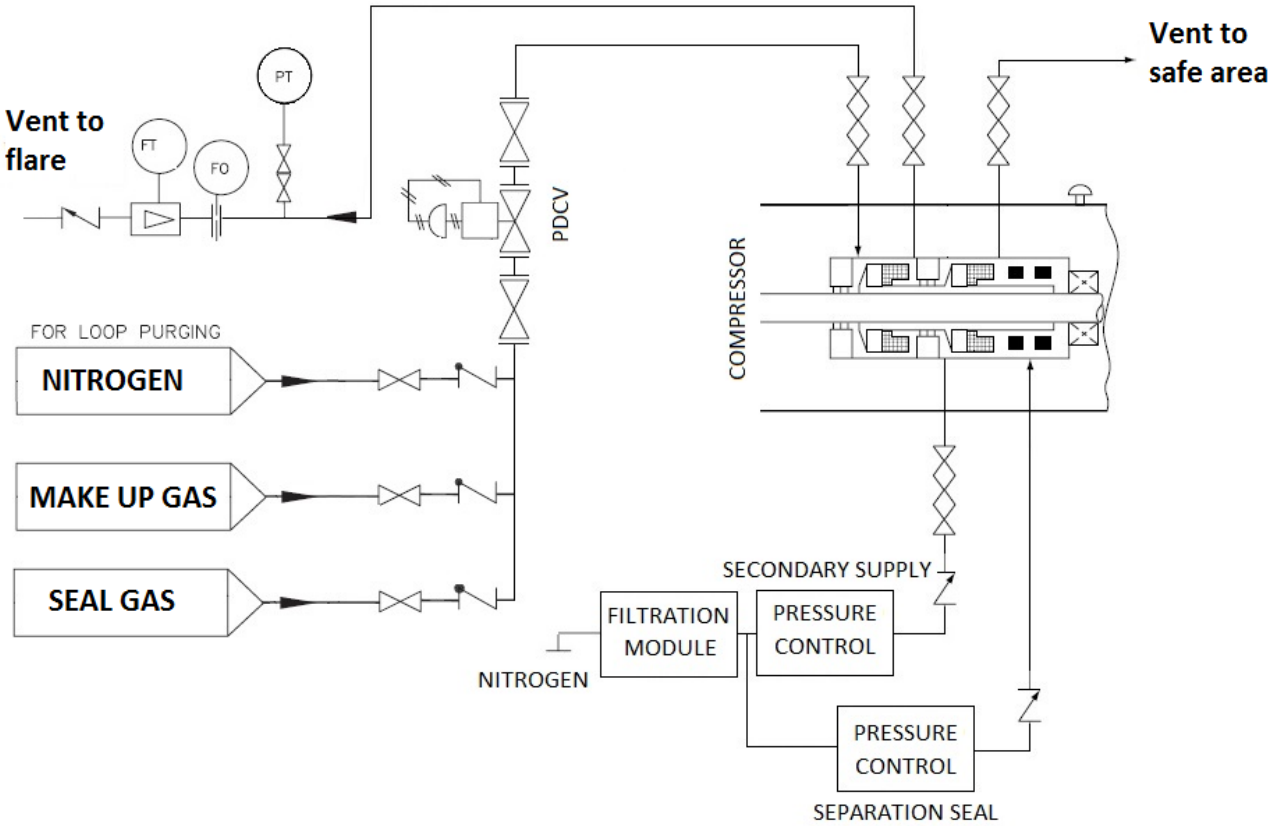
Static pressure: 80.33 kg/cm2 A

Seal Gas Diagram

From Utilities (For Purging)

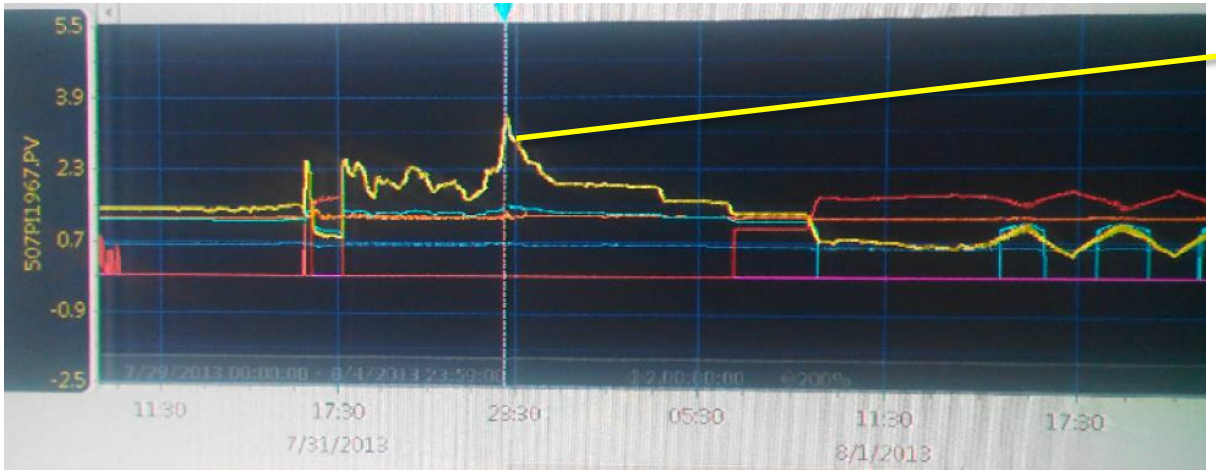
From Make up gas compressor discharge (During Start-up)

From RGC discharge



Sequence of Events

1. On 31.07.2013, RGC tripped on a high process value (Unit upset).
2. Compressor re-start planned in settle out condition.
3. Make up Gas (MUG) compressor discharge lined-up to primary seal gas supply.
4. After the RGC start-up (on 31.07.2013), DE side DGS - primary seal vent pressure increased to 3.3 kg/cm2 g (Alarm limit of 3 kg/cm2 g). Same location vent flow also increased to 35-36 Nm3/hr.

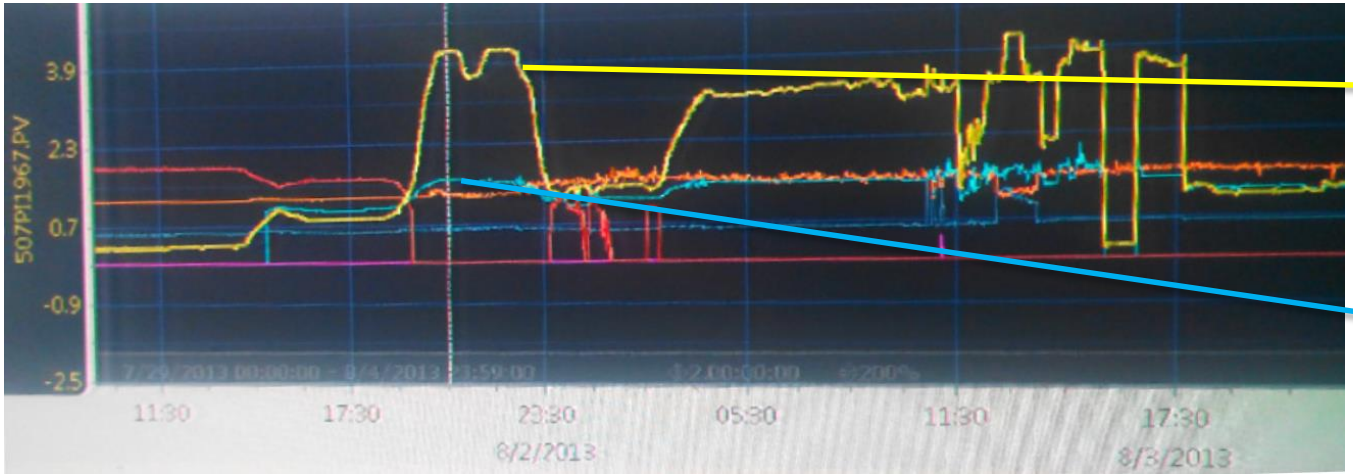


DE side primary seal vent pressure

Sequence of Events

5. Compressor was kept in operation

6. On 02.08.2013, DE side primary seal vent pressure and flow further increased to 4.2 kg/cm2g and 37 Nm3/hr respectively. Subsequently DE side secondary seal flow also dropped due to high primary seal vent pressure.



6. Compressor was shutdown for dry gas seal inspection/replacement job

Observations during maintenance

1. DE Side seal found with the heavy oil ingresses
2. Seal gas supply ports flooded with oil
3. NDE seal also found contaminated with oil

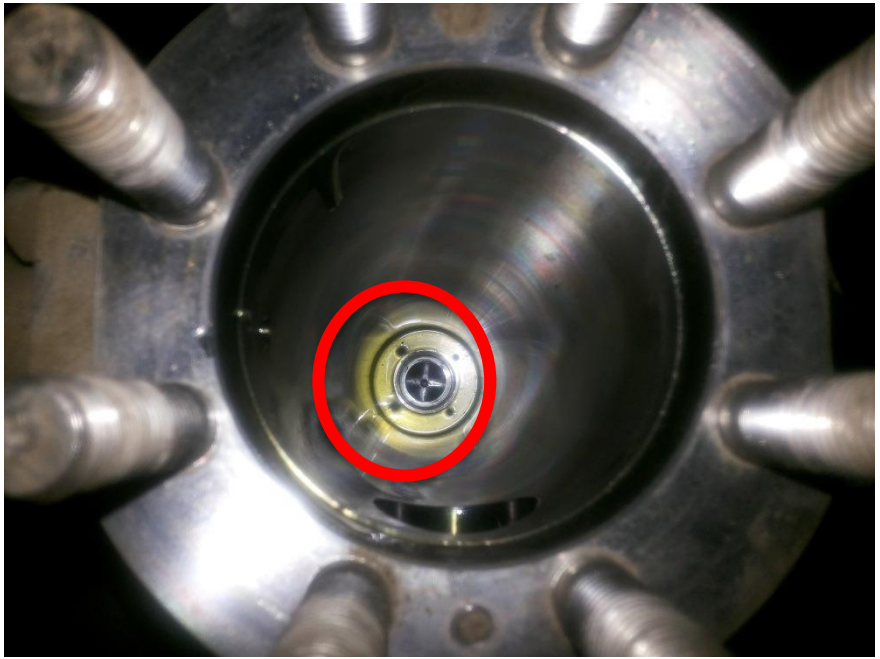
Seal gas supply port

Observations during maintenance

4. Oil found in seal gas filter housing

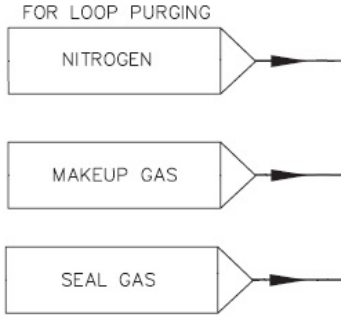
5. Carbon particles in the DE side seal, presumed to be from seal face

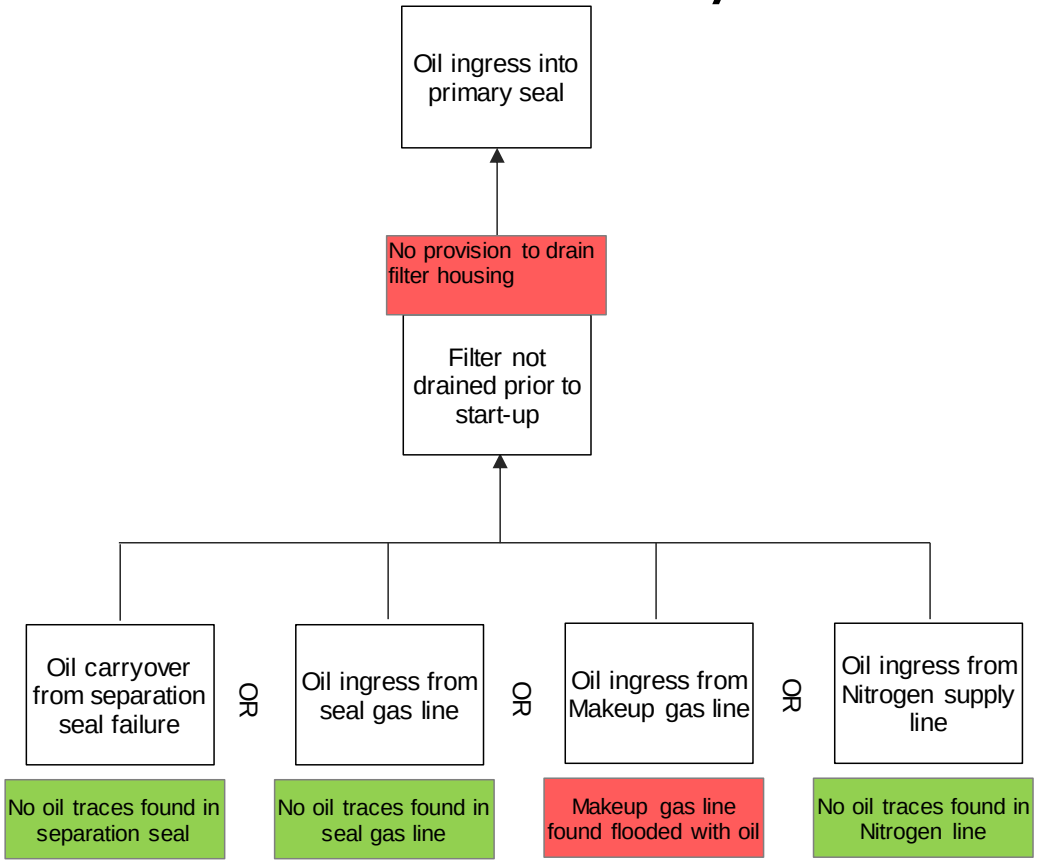
6. NO traces of oil in the separation seal system



Filter Housing

Failure Analysis





Failure Analysis

- Make-up gas (Hydrogen) is supplied from a makeup gas compressor discharge, which is a reciprocating machine
- Make up gas compressor has Lubricated cylinder design
- Oil found in the pipeline from Make-up Gas compressor discharge and also in its inter-stage knockout drum.
- Seal gas filter were designed to remove moisture but no safe draining provision in filter housing.
- Above led to oil entry into Dry Gas seal , resulting into its failure

Recommendations

1. Provision of separate primary seal gas supply line from hydrogen bullet (storage) for compressor start-up / shutdown case, in place of make up gas compressor discharge gas.
2. Provision of safe seal gas filter draining mechanism
3. Update project stage specifications to include coalescing filters in seal gas supply along with filter drain pots to collect condensed liquid

Corrective actions

1. Compressor both ends dry gas seals replaced with spare seals, pipe lines cleaned, filters replaced.
2. A dedicated pipeline erected from hydrogen storage bullet to supply clean hydrogen for primary seal during start-ups. Original make-up gas compressor discharge line for primary seal disconnected and blinded off.
3. Safe filter draining provision provided and being drained at regular intervals.

Performance after the corrective job:

1. Compressor was running normal since replacement of dry gas seal and all seal parameters were normal for four years, after which seal was replaced on preventive basis during Refinery 1st Turnaround (Year 2017). New scheme of pure hydrogen is in line and working fine.

Key Learnings

- Accurate information about gas composition / operating conditions is of utmost importance in project stage specifications. This enables manufacturer to design the most suitable system.
- Validation of project documentations by maintenance / operations team for including practical experiences.
- Involvement of O&M (Operations & Maintenance) teams from project construction stage to study documents, specifications & audits to identify such gaps.
- Even a one instance of small oil ingress can result into immediate dry gas failure. Given the extremely tight running clearances for dry gas seals, absolute cleanliness of gas supplied to the seal faces is required.
- Reliability studies like FMEA/RCM is essential for single line critical turbo-machines during project/ construction stage as downtime is highly expensive.

THANKS

Sincere acknowledgements to the team operations and maintenance, reliability for their efforts and a great show of team-work in quick fault finding, safe and successful execution of the job.